Location of Tevatron RF in the Main Injector Era
and
Clarification of the Tevatron F0 Geonetry

Dave Johnson

Main Injector Department

Fermi National Accelerator Laboratory

May 14, 1993

1 Introduction

The question of the location of the Tevatron Rf cavities in the Main Injector Era has again surfaced. This is driven in part by the need to know the exact placement with respect to the new F0 enclosure, the new RF building, and existing brass plugs and markers so the that penetrations, transmission lines, cable trays, piping, etc. can be located and detailed Title II drawings may be detailed. (John Reid's request).

The location and spacing of the Tevatron RF cavities were specified in the Main Injector Conceptual Design Report (Rev. 1 March 1989 and Rev 2.3 April 1990). This is depicted in Figure 1. This had the centerline of the last cavity (A4) spaced a half-wavelength from the crossing point at F0. However, the location of the crossing point in reference to MR-F0 or TEV-F0 was not specified in this document.

There are two ancillary questions that must be answered to locate the cavities in the tunnel with respect to MR-F0 and TEV-F0 for Title II design. The first is where will the proton-pbar crossing point at F0 be located in the MI Era? And the second is, does the design of the P1 and A1 transfer lines require re-locating the cavities from there conceptual design location due to physical inteferences?

In trying to answer the first question there was a descrepancy between where John Reid and I had located the proton-pbar crossing point at F0. Consequently, we had the cavities located at different positions. I had the crossing point 6" upstream of TEV-F0 and John had the crossing point 7/8" downstream of TEV-F0. Obviously, this descrepancy had to be resolved. What follows was my attempt to find out where these numbers came from and determine what it should be for the MI Era.

2   A Little History:

To locate TEV-F0 with respect to the Tevatron lattice I utilized several lattice files containing the description of the Tevatron with markers for the straight sections. The lattice files of the Tevatron that I had been using (MAD lattice file tev_92.lat and a personal synch file) had a marker .F0 located 26.7494 m downstream of E49 99" quad and 26.4446 m upstream of the F11 99" quad. This marker, .F0, had been interpreted as TEV-F0.

The crossing point had been located symmetrically between the inner quads in the F0 location. More specifically, 26.597 m downstream of the magnetic end of the inner E49 99" quad. (The total separation between the magnetic end of the E49 and F11 99" quads is 53.194 m). The difference between the crossing point (midway between the quads) and the marker .F0 produces a crossing point which appears to be 6" upstream of the marker .F0 (i.e. 26.597 - 26.7494 = -0.1524 m).

3   A Little More History:

The synch file which "is a VAX version taken from Dave Johnson's synch file (CYBER version) for the double low beta design at B0 and D0" is shown in the Appendix. Note the values of LS1, LS2 and LSB1, LSB2. In this lattice file all straight section drifts are anti-symmentric with the upstream drift being 0.3048 m longer than the downstream drift. I have been unable to track down specific reasons for these unequal drifts. (I will not speculate here.) The end of LS1 had been taken as the center of the straight section (i.e. the Tevatron "0" marker). As will be pointed out this is NOT the Tevatron "0" marker. These unequal drift lengths (especially in the normal straight

secthins) have been propagated for many years and are in many "current descriptions of the Tevatron". I questioned Norm Gelfand and his description in TEVLAT seens to be the only lattice file which currently utilized equal lengths for the up and downstream drifts in the "normal" straight sections.

According to TM-1032, "The Revised Great Doubler Shift", all Tevatron straight section markers are to be located at -10.308 inches in the Main Ring coordinate system. Additionally, the magnetic separation between the 49 and 11 99" inner quads of the normal straight section should be 2094.218". This places the "0" marker 1047.109" (25.5967 m) downstream of the downstream magnetic end of the 49 99" quad. Therefore, the straight section insertions (at least the inner quads are placed SYMMETRICALLY about the Tevatron "0" marker (in our case TEV-F0). This geometry is shown in Figure 3, which is page 7 of TM-1032. The magnetic length is 1.831" longer than the steel, so the steel-to-steel separation should be 2097.88". The steel-to-steel separation of the E49 and F11 99" inner quads was measured to be 2097.773" during a (re)survey of F0 in 3/'92. This is actually 113 mils shorter than the design reported in TM-1032.

The relative location of the origional B0 low beta insert was specified in Section 9.2.1 of the "Design Report of the Tevatron I Project". This had the insertion located symmetrically about the "long straight section B0". Furthermore, it states that the "maximum luminosity point (is) 0.9 inches downstream of Tevatron B0 for the final low beta of 1 m." This implies that the proton-pbar crossing point (longitudinally) at B0 is approx 7/8" downstream of the TEV-B0, defined to be at -10.313".

Furthermore, the location of the D0 collision hall and detector was specified in a memo by D. Finley (dated 10/19/84) to be -10.313 inches in the Main Ring coordinate system. This memo is included in the Appendix. He investigates the relative maximum luminosity points at B0 and D0 and points out that the "important point to keep in mind" is the relative locations of the RF cavities, B0 detector, and D0 detector. The implication here is that the proton-pbar crossing points at these locations should be each separated by 1/3 the circumference of the Tevatron.

The value for the crossing point at F0 of 7/8" downstream of TEV-F0 that was used by John Reid was obtained from meeting between H. Edwards and the RF group (12/6/83) specifying the locations of the Tevatron cavities for the Collider (see D. Finley memo in Appendix).

So, this 7/8" offset in the downstream direction of the crossing point at F0

3

and the maximum luminosity point at B0 are consistent with the separation being 1/3 the circumference.

4   CURRENT INSTALLATION:

During the shutdowns in Fall of 1990 (and early Spring 1992) the new B0 (and D0) low beta inserts were installed. These were designed as matched symmetric insertions centered about TEV-B0 and TEV-D0. Since the low beta insertions are symmetric, the maximum luminosity point isdefined to be at TEV-B0 and TEV-D0. The Tevatron RF was not moved and the crossing point at F0 remained 7/8" downstream of TEV-F0.

5   THE MAIN INJECTOR ERA:

When the location of TVE-60, and hence MI-60, was defined in MI note 00047, S. Peggs used the 26.4446 m drift as the separation between TEV-F0 and the F11 99" quad. The TEV-60 point was defined to bisect the 26.4446 m drift space, hence TEV-60 was defined to be 13.222 meters downstream of TEV-F0. This actually has little or no impact on the location of the MI or the beamline design but, we should be aware that MI-60 is not located at the bisector of the downstream half of Tevatron F0 straight section.

The location of the crossing points at B0, D0, and F0 should separated by exactly 1/3 the circumference of the Tevatron. This corresponds to 1113/3 = 371 wavelengths (buckets) or 2094.3951 m. Since the B0 and D0 inserts are centered on TEV-B0 and TEV-D0, the crossing point at F0 should be defined as TEV-F0.

The geometry of the Tevatron F0 region is shown in Figure 3. This shows the locations of MR-F0, TEV-F0, TEV-60, and the design location of the Tevatron RF.

The locations of the devices in the matching section of the current designs of the P1 and A1 beamlines is shown in Figure 4.

6 SUMMARY:

1. TEV-F0 is located 10.308 inches upstream of MR-F0.

2. The location of TEV-60 is 13.222 m downstream of TEV-F0.

3. The location of the proton-pbar crossing point at F0 should be defined as TEV-F0.

4. The location of the Tevatron RF cavities should be as specified in the MI Conceptual design report and as shown in Figure 1.

5. The current design of the P1 and A1 beamlines does not produce any physical inteferences with the cavities or Tevatron magnets and should not require the Tevatron RF cavities to be shifted from their design locations. The Tevatron F0 straight section with teh P1 and A1 beamlines is shown in Figure 4. (Note: the scale on this figure does not easily allow inteference checking by eye.)

6. To prevent confusion in the furture, the lattice files which describe the Tevatron straight sections should be modified to use equal upstream and downstream straight section drift lengths of 26.59657 meters such that the straight section markers acurately reflect the TEV "0" markers. If maximum luminosity points are found to not correspond to the "0" markers, additional markers "MAX_LUM" should be inserted in the lattice files.
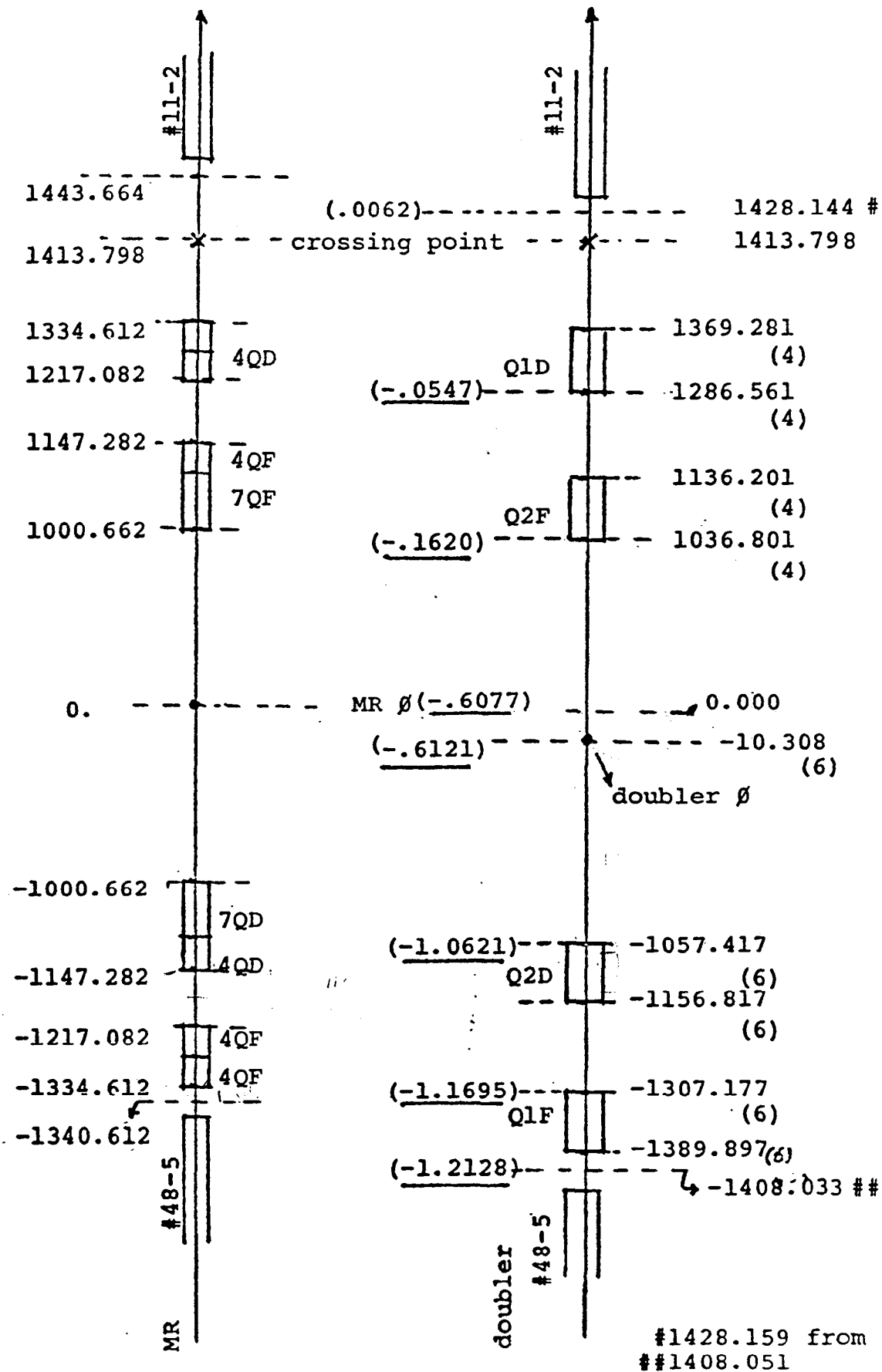
5

Figure 1: Tevatron RF spacing
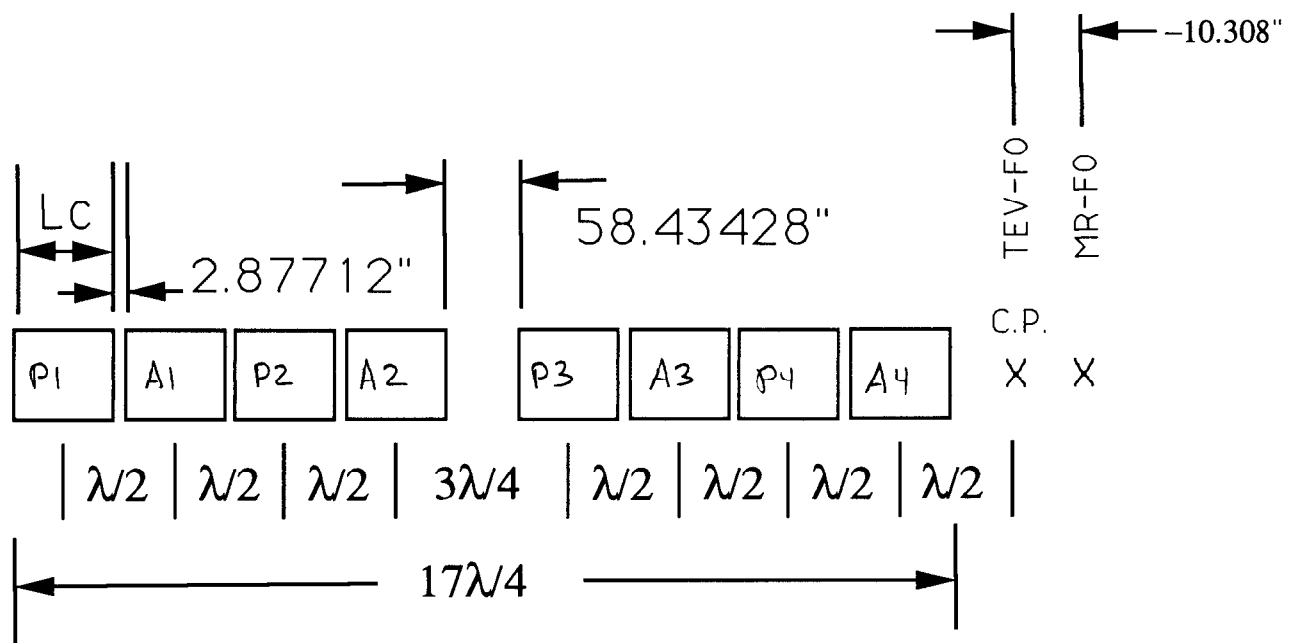
λ = c / RF freq = 2.99792458 E8 /53.1050716 E6
= 5.64526982 m = 222.245717 inches.

$\lambda/2$ = 111.127359 inches

L c = 108.25 inches (physical length of cavity)

normal long _craight (BØ, CØ, EØ, FØ)

#11-2

#11-2

1443.664

(.0062) —————— 1428.144 #

1413.798 ——×—— crossing point ——×—— 1413.798

1334.612 ⎤ 1369.281
     4QD (4)
1217.082 ⎦ (-.0547) —— 1286.561
         (4)

1147.282 ⎤ 4QF 1136.201
     7QF (4)
1000.662 ⎦ Q2F (-.1620) —— 1036.801
            (4)

0. ————— MR Ø (-.6077) —— 0.000

(-.6121) —— -10.308
         (6)

doubler Ø

-1000.662 ⎤ 7QD

-1147.282 ⎦ 4QD (-1.0621) —— -1057.417
         Q2D (6)
              -1156.817
                (6)

-1217.082 ⎤ 4QF

-1334.612 ⎦ 4QF (-1.1695) —— -1307.177
         Q1F (6)
-1340.612   -1389.897 (6)

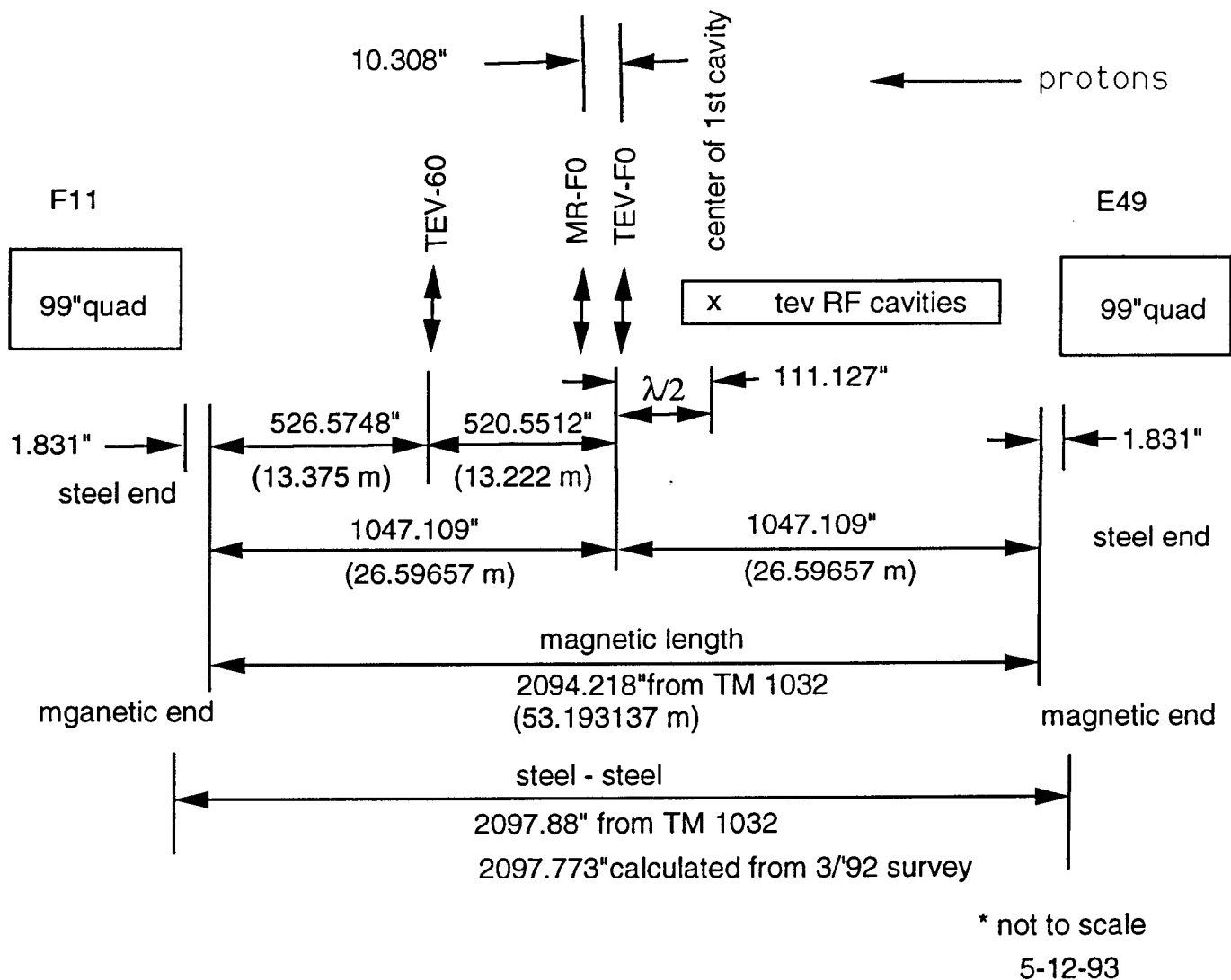#48-5 (-1.2128) —————— -1408.033 ##

doubler #48-5

MR

#1428.159 from SYNCH.
##1408.051 " .

Figure 3: Geometry of the Tevatron F0 region